Quality Assurance of Weather Data and the Probability of Favorable Weather for Prescribed Fire in Alaska.

A proposal submitted in response to JFSP AFP 2004-2 / Task 1

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Alaska Dept. of Natural Resources Divison of Forestry, Northern Region

Other Supporting Letters (attached):

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Abstract: Please see next page.

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Abstract

This proposal is in response to the Joint Fire Science Program's Announcement for Proposals 2004-2, Task 1, "directly address[ing] local knowledge gaps associated with planning and implementation of … fuels treatment … that are specifically identified by an agency administrator." At the request of the Alaska Wildland Fire Coordinating Group (AWFCG), as and the State of Alaska Department of Natural Resources Division of Forestry Northern Region, we will correct data availability and quality assurance problems surrounding the Alaskan Remote Automated Weather Station (RAWS) and other weather station data, as well as the lack of prescribed fire and forecast tools associated with the lack of quality assured weather station data. The sum total of this work will not only directly benefit Alaska, but will also provide a suite of tools that can be distributed to provide benefits in other locations.

Problem Statements

Problem statements / letters of need are attached directly after this page from both the Alaska Wildland Fire Coordinating Group as well as the State of Alaska Department of Natural Resources Division of Forestry Northern Region office. A letter of support is attached at the end of the proposal from Larry Bradshaw of the USDA Forest Service Rocky Mountain Research Station.

1. INTRODUCTION

This proposal focuses on the Joint Fire Science Program's Announcement for Proposals 2004-2, Task 1, "directly address[ing] local knowledge gaps associated with planning and implementation of … fuels treatment … that are specifically identified by an agency administrator." At the request of the Alaska Wildland Fire Coordinating Group (AWFCG), whose members include the BIA, BLM, NPS, FWS, and USFS (see Table 1), as well as the State of Alaska Department of Natural Resources Division of Forestry Northern Region, **we will correct data availability and quality assurance problems that have characterized the Alaskan Remote Automated Weather Station (RAWS) and other weather station data. We will then use these data to produce value-added, tailored tools for land managers** to use in creating prescribed fire fuel treatment plans. Needs letters/problem statements from both groups are attached, as is a supporting letter from Larry Bradshaw of the USFS Rocky Mountain Station.

1a. Project Justification

Alaskan land managers interested in using prescribed fire cannot use many of the tools available to land managers in other areas due to the extremely limited amount of Alaskan RAWS and other station data in the National Interagency Fire Management Information Database (NIFMID) and its associated systems, the Weather Information Management System (WIMS) and the data retrieval program KCFAST. Tools such as Fire Family+ and the Rare Event Risk Assessment Process (RERAP), that are used in determining quantities of interest for prescribed fire and timing of likely prescriptive windows, require data retrieved from the NIFMID database in their calculations. The lack of comprehensive local Alaskan observations within NIFMID means that managers cannot use these tools without extensive error checking and reformatting of whatever observations they might obtain elsewhere. This data quality assurance and repackaging effort is often prohibitive, resulting in the Alaskan RAWS and other

Table 1: ALASKA WILDLAND FIRE COORDINATING GROUP (AWFCG) MEMBERS

U.S. Department of Interior
- Bureau of Indian Affairs
- Bureau of Land Management
- National Park Service
- US Fish & Wildlife Service

State of Alaska
- Department of Natural Resources Division of Forestry
- Department of Fish & Game
- Department of Environmental Conservation

U.S. Department of Agriculture
- U.S. Forest Service

Native Organizations
- Association of Village Council Presidents
- Bristol Bay Native Association
- Chitina Village Tafitional Council
- Chugachmiut corporation
- Tanana Chief Conference

station network information not being used to its full benefit. Further, all national analyses based on NIFMID data (e.g., Andrews et al., 2003) are necessarily incomplete because of the lack of Alaskan data within NIFMID.

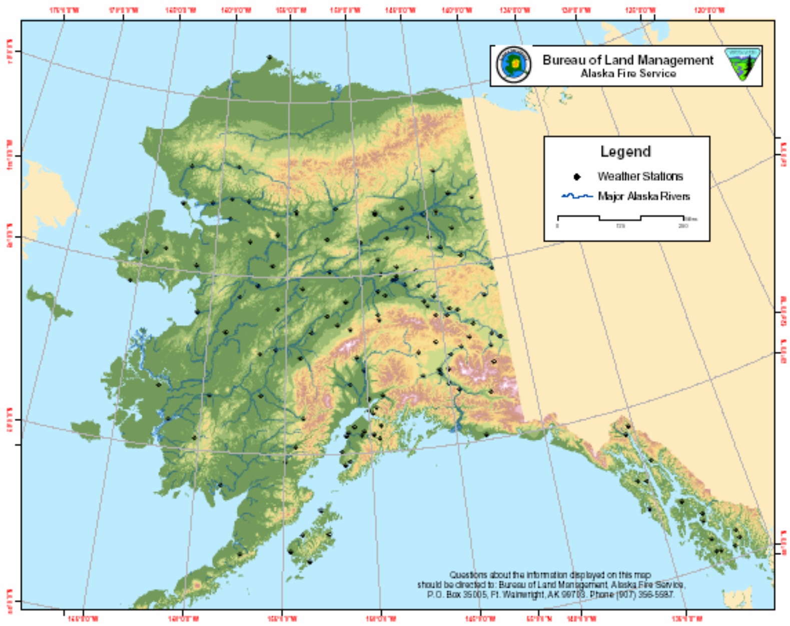

Figure 1: Locations of current Alaskan RAWS stations. In addition to the nearly 100 current RAWS stations there are many other weather stations that may be useful to land and fire managers (see Table 2). Map provided courtesy of the Alaska Fire Service.

Additionally, Alaskan land and fire managers primarily use the Canadian Forest Fire Danger Rating System (CFFDRS), with a few areas using the National Fire Danger Rating System (NFDRS), when working with both prescribed fire and wildland fire use scenarios. Current national tools, such as RERAP, do not include CFFDRS indices in their probability calculations. This leaves Alaskan fire and land managers without detailed assessments of prescription window probabilities, which makes the creation of prescribed fire plans more difficult, and limits the likelihood that prescribed fire treatment goals will be accomplished.

The lack of quality assured weather data also detracts from the ability of the Alaska Interagency Coordination Center (AICC) to predict and plan for both prescribed burning and dangerous wildfire conditions. While other regional GACCs, notably the Northwest Coordination Center have made great advances in prediction of fire danger, the AICC has necessarily lagged behind.

The following proposal addresses all of the above needs and issues. As laid out below, we will first quality assure and routinely make available Alaskan weather station observations through a web site and through NIFMID. This process will be done with "one-click" user tools and automated processes to ensure that quality assured data are available in near real-time in the future. Next, we will supply Alaskan land managers with an integrated web tool to both determine and maximize the likelihood of planned prescription windows occurring. Finally, we will jump-start the AICC's ability to predict both prescribed fire prescription conditions as well as wildfire danger by combining statistical relationships with forecasts from existing climate models. The sum total of this work will not only directly benefit Alaska, but will also provide a suite of tools that can be distributed to provide benefits in other locations.

1b. Project Objectives

Table 2: Alaskan Stations By Type

Station Type	Organization(s)	Number
RAWS	various	97+*
NFDRS	State of Alaska Forestry	7
ASOS / AWOS	FAA / NWS / Air Force	112
APAID	FAA / NWS	21
SNOTEL/SCAN	USDA NRCS	74
COOP	NWS / Community	460+
Other (SAWRS, etc…)	Military / DOT / Private / etc…	20+

* number of RAWS stations varies due to portable RAWS placements

The project will have several **objectives**:

- Collect and quality assure the historical Alaskan RAWS observations;
- Input the quality assured observations into WIMS/NIFMID; and
- Create an automated system to ensure new Alaskan RAWS observations are quality assured and inserted into WIMS/NIFMID in a timely fashion.

Additionally, we will use the quality assured dataset to develop tools for land managers interested in prescribed fire windows (see Section 2 for details):

- Create a web-based tool that compares the likelihood of finding prescription windows based on ranges of weather variables and CFFDRS and NFDRS components;
- Determine monthly and seasonal statistical relationships for conditions favorable for common prescription window occurrence; and
- Use the above relationships together with climate forecasts to predict the likelihood of conditions favorable to prescriptive treatments at lead times of up to 1 year.

The result of this work will provide **benefits** on several levels:

- Better ability to plan prescribed burns and manage wildland fire use fires in Alaska;
- Access to quality controlled Alaskan historical and on-going data;
- Availability of Alaskan data through NIFMID;
- Placement of additional Alaska stations in NIFMID;
- Existence of a direct CFFDRS / NFDRS comparison dataset for Alaska;
- Inclusion of Alaska in national assessments using NIFMID; and
- Enhanced prescription window and fire danger forecasts through the AICC.

Additionally, this project will directly benefit work proposed by Rorig, Ferguson, and Yoshikawa, "Duff Moisture and Fire in Alaska: Validating Fire Danger Indices" in their proposal currently submitted to the Joint Fire Science Program under AFP 2004-2 Task 1, by providing quality controlled station data that can be used to determine the temporal and spatial variability of contributing factors to Duff Moisture and Fire Danger Indices.

1c. Background

Currently, hourly RAWS observations are collected from the nearly 100 stations around Alaska. These data are uploaded via satellite to the ground station at Wallops Island, VA and sent through Boise, ID to the Alaska Fire Service (AFS) in Fairbanks. The collected data are then stored by AFS and used to calculate the Fire Danger using the Canadian Forest Fire Danger Rating System (CFFDRS).

The AICC in Fairbanks is responsible for entering a subset of about 65 RAWS observations as NFDRS observations into the WIMS database. State of the weather and lightning activity levels must be manually determined before these observations can be entered as NFDRS observations into WIMS. In addition, about 35 non-RAWS observations are also entered into WIMS as NFDRS observations. Currently, all this data must be entered manually into the WIMS site in order to be stored in the NIFMID database. Given limited manpower, the effort to enter this data is often prohibitive.

The methods, agencies and individuals responsible for entering this data have varied over the last 10 years with some geographic areas and some years entirely missing. To date, observations have been entered only for the time period of May 1st through August 31st. This omits considerable amounts of data of interest to land managers such as late season data, and season ending events. The above problems emphasize the need for the work described in this proposal.

2. MATERIALS AND METHODS

The project will consist of 4 parts:

- gathering data;
- quality assuring / quality controlling the data;
- creating prescription window statistics; and
- map typing and seasonal forecasting.

We discuss each part in turn.

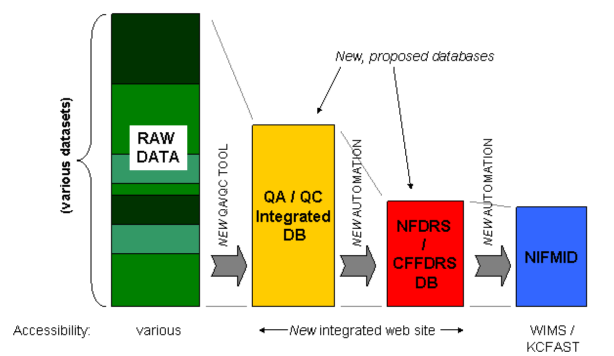

Figure 2: Relationship of proposed databases, proposed QA/QC tool, and proposed automation tools to existing raw data and NIFMID/ WIMS/ KCFAST. The raw data are currently accessible only as separate databases from various locations.

2a. Gathering Data

Initially, historical RAWS data will be collected from archives at the Western Regional Climate Center (WRCC) and the Alaskan Fire Service (AFS). Additionally, we will gather all point observation data within Alaska from non-RAWS stations (see Table 2). These data include daily observations from the ASOS and AWOS networks, as well as SNOTEL and COOP stations. Many of these data are archived, albeit in separate datasets, at the WRCC, others at the USDA NRCS. Where possible we will also obtain private weather observations and Alaska Department of Transportation observations. An automated process will be created at the AFS to FTP additional data on a daily basis back to a central project archive at the Pacific Wildland Fire Sciences Laboratory. The raw data will then be reformatted and placed into a standard, platform independent NetCDF format file, which will be regularly backed up to a tape archive.

2b. Quality Assuring / Quality Controlling the Data

The data flow through the system is shown in Figure 2. Raw data will be examined and a quality assured / quality controlled integrated database will be created. Where possible, NFDRS and CFFDRS computations will be performed and placed in a supplemental database. Finally, appropriate observations will be placed into the WIMS/NIFMID national database.

Quality assurance / quality control of the database will be done by a combination of automated processing and human oversight. Several automated programs will examine the data searching for outliers, possible errors, and bad or missing data. The automated programs will categorize each data point as:

A. Consistent with no reason to question;
B. Unusual, but likely to be okay;
C. Unusual, and unlikely to be okay;
D. Unphysical (outside possible range).

Data in category A will be automatically kept, while data in category D will be automatically rejected. Data in category B or C will be examined in context and the user will be allowed to determine whether to keep or reject it. An undergraduate student at the University of Alaska will do the initial examination and present recommendations as to whether to accept or reject data, but all final decisions will be made by all three principals (Larkin, Alden, and Shulski). In this way a "best judgment" QA / QC database will be constructed. However, this database will include markers that explain all flags examined and the reason for keeping or eliminating the data point, so that later users can refilter the database to suit their own needs, or apply newer quality assurance routines.

To check and flag the data, we will initially obtain software written by Beth Hall and the Desert Research Institute to quality control California RAWS observations. This software is designed to look at each station individually and look for unphysical data (outside possible range, e.g., negative wind speed), as well as data spikes and long term identical data points (stuck sensors continuously reading one value). Modifications will be made to this C++ and PERL code in order to add additional flags comparing the data point to historical observations at that location, as well as to compare data spikes in one variable with concomitant changes in associated variables (e.g. rapid temperature changes with changes in wind direction).

We will also write new programs that will examine each observation in context of nearest neighbor observations. While several variables (such as wind speed) will not follow nearest neighbor values, others (such as pressure and temperature) are more likely to do so. Additionally, use of neighboring observations will allow us to account for fluctuations due to the passing of fronts, etc. Neighboring stations will be weighted in this comparison based on distance of separation and direction of separation and will be adjusted and weighted for elevation differences.

After the data have been flagged as either category B or C, users of the system will be presented with a web interface that contains both text and graphical displays of the data in question and surrounding data context. The exact display will vary depending on the exact flag tripped (e.g.

unusual compared to neighbors vs. unusual spike in time) but a prototype display is shown in Figure 3. On the interface the user will be presented with a "one-click" ability to accept, reject, or temporarily skip (come back to later) the data. As no retyping of the data will be necessary and the contextual information will already be displayed, this will greatly speed the rate at which the disposition of data can be determined. It may also be possible to group data by flag type for certain situations (such as a stuck sensor). The goal is to make the quality assurance process as quick and easy as possible, enabling on-going data to be quality assured with only a minimal (~1 hr/week) effort.

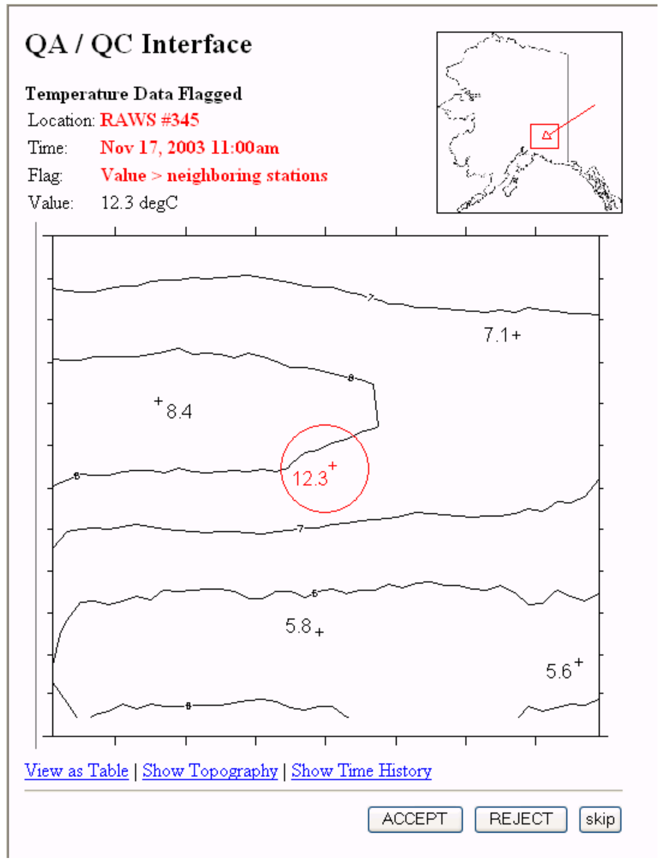

Figure 3: Prototype user interface for the QA / QC tool (example only). The tool will present the flagged data in graphical context and provide "one-click" functionality.

After the data are accepted into the QA/QC database, programs will automatically compute the CFFDRS and NFDRS components if the data are sufficient to do so. State of the weather and lightning activity data needed for the NFDRS calculations will be automatically extracted from additional databases maintained by the AFS. Once CFFDRS and NFDRS calculations are performed, these resulting values will be saved into a supplemental NFDRS / CFFDRS database.

Finally, where appropriate, these observations will be stored into the NIFMID national database using WIMS. For the historical observations, the data for NIFMID will be collected and then presented for examination and approval to the NIFMID database administrators. Larry Bradshaw of the USDA Forest Service Rocky Mountain Station has volunteered to help facilitate this transfer. Once a system is set up for quality assuring data on a regular (near real-time, such as once or twice a week) basis in year 2, the WIMS input will be done through an automated process.

We expect that the quality assurance / quality control procedure will be iterative, and that additional quality control programs will be developed throughout the project span. Thus we will deliver quality controlled data to NIFMID in two steps. An initial quality controlled dataset will be delivered at the end of year 1, and a final quality controlled dataset will be delivered at the end of year 2. This is done to avoid prolonged delays before quality controlled data for Alaska are available through NIFMID.

2c. Creating Prescription Window Statistics

After the historical data has been initially quality controlled, we will provide a web tool that can use the historical data to show the probability that a user-defined prescription window range will occur throughout the year. While the final design will be worked out with the Alaska Wildland Fire Coordinating Group (AWFCG) and the State of Alaska Department of Forestry, a prototype interface for this tool is shown in Figure 3. A user will be able to specify ranges of values for combinations of weather variables, NFDRS components, and CFFDRS components. The tool will then produce probabilities of this combination of ranges occurring throughout the calendar year by scanning through the historical data.

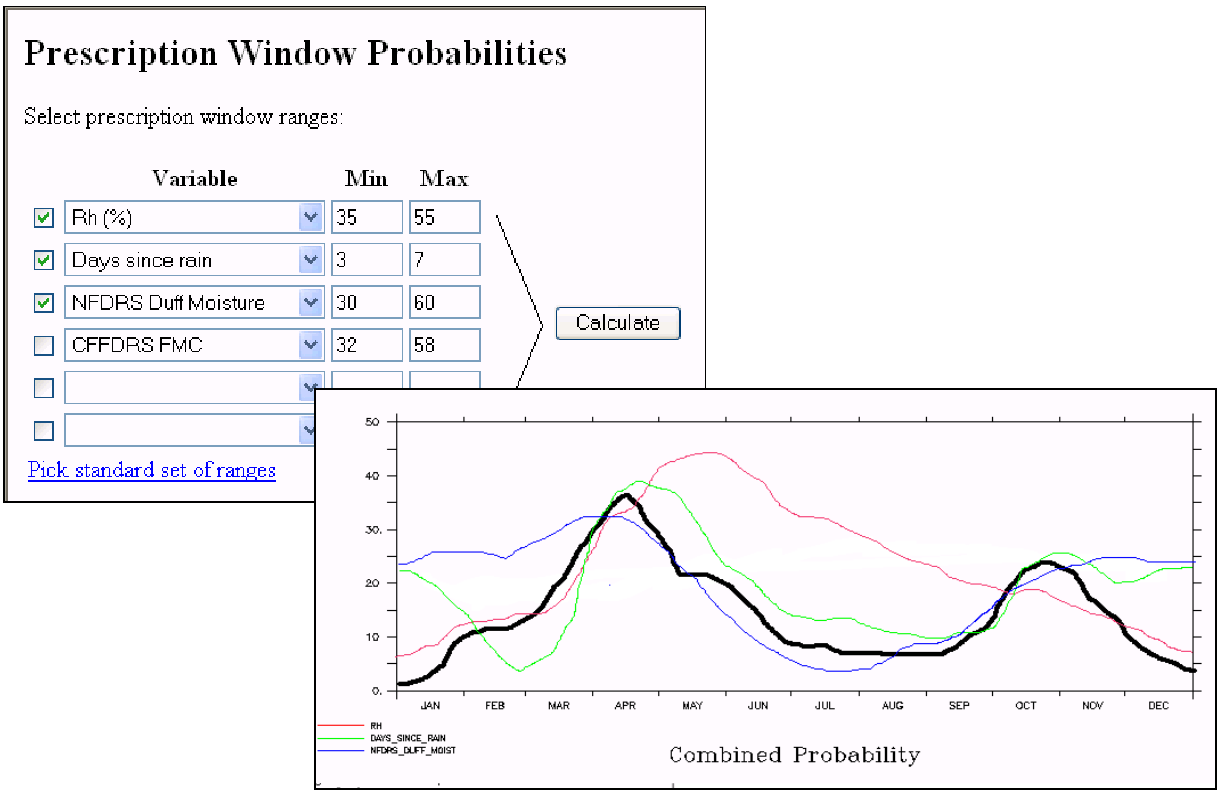

Figure 4: Prototype input and output of prescription window probability calculator (example only). The user will be able to select any combination of variables, specify the range limits, and see which variables are limiting to the combined probability of occurrence.

This tool differs from the RERAP program in several important ways. While it is not intended to replace RERAP, these differences are important for Alaskan land managers to utilize the historical data to optimize prescribed fire treatment plans. First, the proposed tool will work off of a quality controlled dataset that contains not only RAWS data intended to be stored in NIFMID, but, at the option of the user, will also utilize all other collected / quality controlled station data as well. This is important because the RAWS data are only a small subset of the overall available Alaskan station data, and adding in the other station data will better enable the tool to cover the vastness of Alaska. Second, it will allow the user to specify ranges of CFFDRS values to use, which are not present in RERAP. Third, the simple interface (web based, with no downloading of data necessary) will provide a quick way for land managers to compare overall probabilities from different possible prescription combinations, thus enabling land managers to quickly tune prescription window definitions to match the highest likelihood of success.

2d. Map Typing and Seasonal Forecasts

The Alaska Interagency Coordination Center (AICC) is responsible for providing meteorological support for both prescribed fire and wildfire. With only one meteorologist and no quality assured historical database, the AICC has not been able to benefit from fire danger forecast techniques that have proved useful in other regions, such as the map typing and climate associations found by Terry Marsha and others at the Northwest Coordination Center. We propose to help jump start and supplement efforts by the AICC to predict variables important for prescription windows.

Specifically, we will look for statistical relationships between frequencies of commonly used prescription window variable ranges occurring and synoptic scale weather patterns. Recent studies (e.g. Vecchi and Bond, 2003) have indicated that there are significant associations between large-scale climate variability and weather in Alaska and other high-latitudes. Utilizing statistical techniques such as correlation analyses and principal component (PCA) / empirical orthogonal function (EOF) analyses, we will document links between large-scale atmospheric patterns and weather patterns of interest to prescribed fire and wildfire. The weather variables will come from the generated QA / QC dataset; the synoptic variables will be taken from the NCEP / NCAR Reanalysis dataset.

We will then couple these statistical relationships with climate model forecasts produced by the International Research Institute for Climate Prediction (IRI) and the National Center for Environmental Prediction (NCEP) to begin forecasting the likelihood of weather favorable for prescriptive treatments occurring. We will also examine the probabilities of season ending events occurring and begin forecasting the end of the fire season. Additionally, we will help the AICC examine wildfire danger forecasts. These forecasts are a necessary step to implementing tailored, usable climate forecast related products for Alaskan fire and land managers.

<u>3. SCIENCE DELIVERY AND APPLICATION (TECHNOLOGY TRANSFER)</u>

Technology transfer will consist of several parts:

- A **project website** detailing the work being done will be set up almost immediately. The website will provide access to all databases and tools developed for the project.
- **Presentations** about the project will be made each year in October at the **Alaska Interagency Fall Fire Review**, a central meeting well attended by Alaskan land and fire managers. The Alaska Interagency Fall Fire Review will also provide a place to showcase tools, train Alaskan managers on their use, and obtain feedback.
- A **presentation** will also be made at the 2005 6TH Fire and Forest Meteorology conference of the American Meteorological Society.

- In year 2, a **journal article** will be prepared for publication in a scientific journal such as the Journal of Applied Meteorology or the International Journal of Wildland Fire.
- **Documentation and packaging** of all quality assurance programs and interfaces will be prepared so that the tools developed here can be applied elsewhere.
- **Data access** to all created datasets (such as the quality controlled data) will be supplied through both a web and FTP interface.
- **Data access** will also be available through the WIMS and KCFAST interfaces to all data input into NIFMID.
- **Email and phone support** will be provided to members of the Alaska Wildland Fire Coordination Group and the State of Alaska Department of Forestry. This will be provided on an on-going basis through S. Alden and the AICC.

The **underlying technologies** behind the quality assurance / quality control user interface and the prescription window probability generator will consist of PHP and PERL CGI scripts on an Apache web server communicating with C++ optimized code to quickly scan the NetCDF datasets. GnuPlot, GMT, or other similar software will be used to create map and timeseries graphics where needed. All of these technologies are open source, and will run on LINUX operating system. This will mean that the entire bundle of programs and scripts necessary to set-up and run the quality assurance / quality control software and prescription window probability generator will be both portable and cheaply duplicated.

Web servers will be located at the Pacific Wildland Fire Sciences Laboratory in Seattle, Washington and utilize a high speed internet connection provided by a collaborative agreement with the University of Washington.

4. QUALIFICATIONS OF INVESTIGATORS

The project will be lead by Dr. Sim Larkin of the USDA Forest Service AirFIRE team in close collaboration with Sharon Alden of the Alaska Interagency Coordination Center and Dr. Martha Shulski of the University of Alaska, Fairbanks Climate Research Center. Curriculum Vitaes for Larkin, Alden, and Shulski are attached. Beth Hall of the Desert Research Institute in Reno, Nevada will also collaborate, lending her expertise.

Dr. Larkin is a Research Physical Climatologist with extensive experience in large data set data analysis and statistical analysis of climate impacts including weather/fire/climate relationships. Dr. Larkin and the AirFIRE team have extensive experience with creating web applications for land and fire managers including a including the JFSP award winning Ventilation Climate Information System (VCIS) project (http://www.fs.fed.us/pnw/airfire/vcis/) and the National Fire Plan BlueSky Smoke Modelling Framework (http://www.fs.fed.us/bluesky). Sharon Alden is the Fire Weather Meteorologist for the Alaska Interagency Coordination Center. Ms. Alden works closely with Alaskan land and fire managers and generates the Alaskan fire danger forecasts. Dr. Martha Shulski of the University of Alaska, Fairbanks Climate Research Center has extensive experience with quality controlling weather station observation data. Dr. Shulski is also responsible for the State of Alaska's climate atlas. Beth Hall is a Research Meteorologist at the Desert Research Institute and has worked on quality assuring the California RAWS data.

Work on quality assurance programs will be divided between Fairbanks and Seattle, with Dr. Shulski primarily responsible for the programs to flag the questionable data and Dr. Larkin primarily responsible for the user interface and prescription window statistics programs. All three principal researchers (Larkin, Alden, Shulski) will collaborate to make the final accept/reject decisions on the data. Ms Alden will be the primary liaison to the land and fire management communities and provide guidance on developing all user interfaces. Ms. Hall will provide software used in quality assuring the California RAWS data and lend guidance to quality assurance efforts. Drs. Larkin and Shulski will collaborate on creating statistical links between the quality controlled data and synoptic weather patterns, as well as implementing seasonal forecasts.

Collaboration will be facilitated by video conferencing, conference calls, email, and 2 group meetings (1 in Seattle, 1 in Fairbanks) per year. All three principal researchers (Larkin, Alden, Shulski) have considerable experience with collaborative projects.

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